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*Publication date:*  
2017

*Document Version*  
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

*Citation (APA):*  
Jakobsen, M. L., Thorsteinsson, S., Poulsen, P. B., Riedel, N., Rødder, P. M., & Rødder, K. (2017). *Bifacial PV cell with reflector for stand-alone mast for sensor powering purposes*. Paper presented at 13th International Conference on Concentrator Photovoltaic Systems , Ottawa, Canada.

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# Bifacial PV cell with reflector for stand-alone mast for sensor powering purposes

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## Motivation

Bifacial solar-cell modules can provide a price advantage in production relative to normal solar-cell modules if the effective light collecting area can become twice the area of a normal single-sided solar-cell module of the same size. This can only be achieved by designing an adequate low cost reflector. Particularly, a design which is optimized for local winter conditions has our highest interest.

We intend to use ray-tracing to model and optimize the interaction between the vertical bifacial solar-cell module and vertical reflector designs.

In this work, we demonstrate results on simulating the power gain, using the bifacial PV cell mounted with a retroreflector relative to a bare bifacial PV cell of same size. We will insert solar data into the model. Finally, we will present our first measurements from a prototype of the bifacial PV cell with the retroreflector.

## The model

A profile of the vertical mast (Fig.1(b)) reveals a bifacial PV cell mounted inside a retroreflector. The angles of the two mirrors relative to the PV cell are  $\pm 45^\circ$ . As illustrated in Fig.1(a) the length of the bifacial PV cell is twice the depth of the retroreflector. This allows the PV cell to collect light, which otherwise could escape the retroreflector. The PV-cell and the retro reflector are surrounded by air only. The path of the incoming light is modelled by two ray paths. Either direct incidence of light onto the PV cell or via a reflection in the retroreflector onto the PV cell.

The simulations do include optical losses at reflections at the mirrors (95%) and absorption in dielectric media, such as the covering laminar protecting the PV cell. Two solar models are used: Solar model I has a constant radiance as long as it is above the horizon, while solar model II uses solar irradiance measurements, obtained from a solar station (see Fig.1(c)).

## The results

In Fig.2(a) and Fig.3(a) the normalized irradiance collected by the bifacial PV cell with the retroreflector is simulated at the latitude of Copenhagen ( $55.676^\circ\text{N}$ ), and at three dates: The 23<sup>rd</sup> of June (red), the 10<sup>th</sup> of April and the 21<sup>st</sup> Dec. In Fig. 2(b) and Fig.3(b) and the simulations for the bare bifacial PV cell is plotted as a function of azimuth angle as well, and at the same conditions as Fig.2(b). In Fig.2 the solar model I is used while in Fig.3 the solar model II is used. In the table the power collected through the entire days with solar model I are listed.

In Fig.4 measurements of photovoltaic current from the prototype (Fig.1(d)) of the bifacial PV cell with the retroreflector are plotted as a function of azimuth angle.

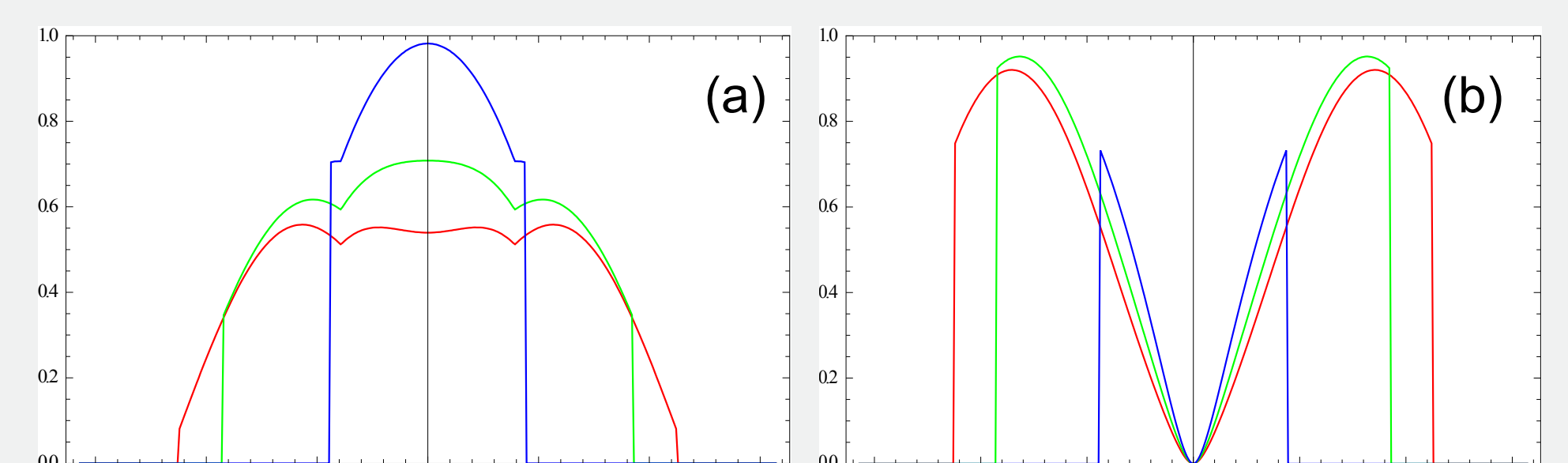


Fig. 2. The simulated normalized irradiance for the bifacial PV cell with reflector and the bare bifacial PV cell, using solar model I.

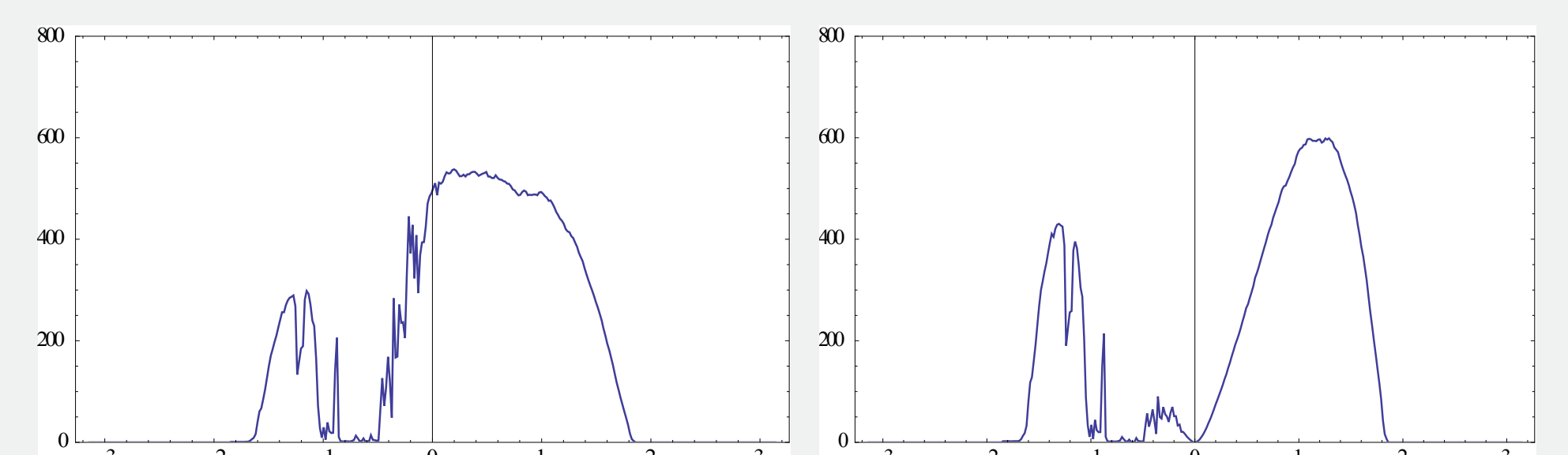


Fig. 3. The simulated normalized irradiance for the bifacial PV cell with reflector and the bare bifacial PV cell, using solar model II.

	Bifacial PV with reflector	Bare bifacial PV cell
June (23/6)	0.328	0.424
April (10/4)	0.348	0.347
Dec (21/12)	0.237	0.102

## Conclusion

An optical raytracing model has been presented to the bifacial PV-cell with a without a retroreflector. The reflector improve the performance of the bifacial PV cell during winter. We have also present our first data from the corresponding prototype.

## Outlook

The model will be developed further in the near future, to include diffuse light, more solar data and different reflector configurations.

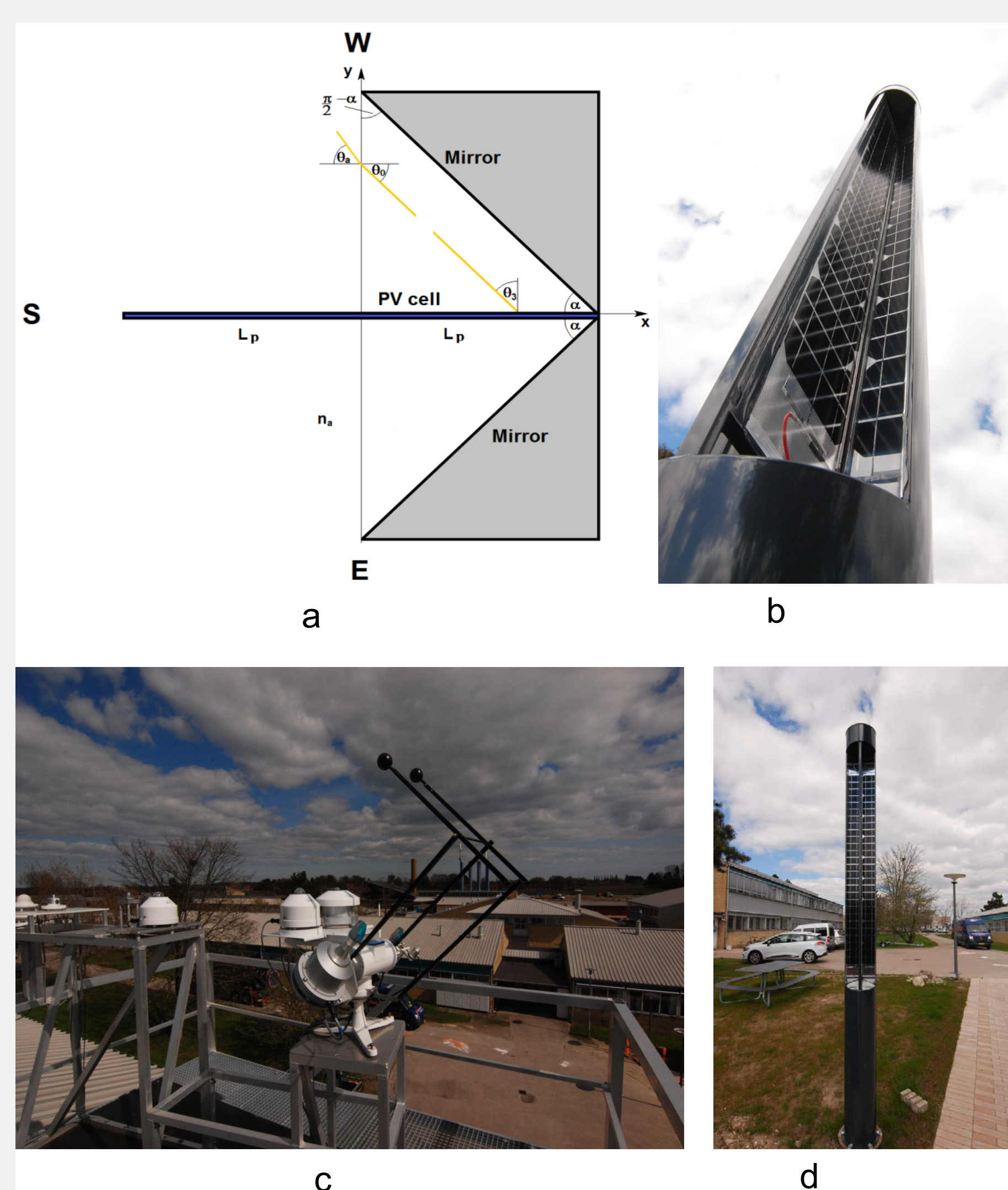


Fig.1 (a). Schematics of the bifacial solar cell and its retroreflector. The profile of the prototype is illustrated in (b). In (c), the solar irradiation measurement station is illustrated. The solar station is mounted above roof height, while the prototype is mounted at ground level (d) being around 10 meters apart.

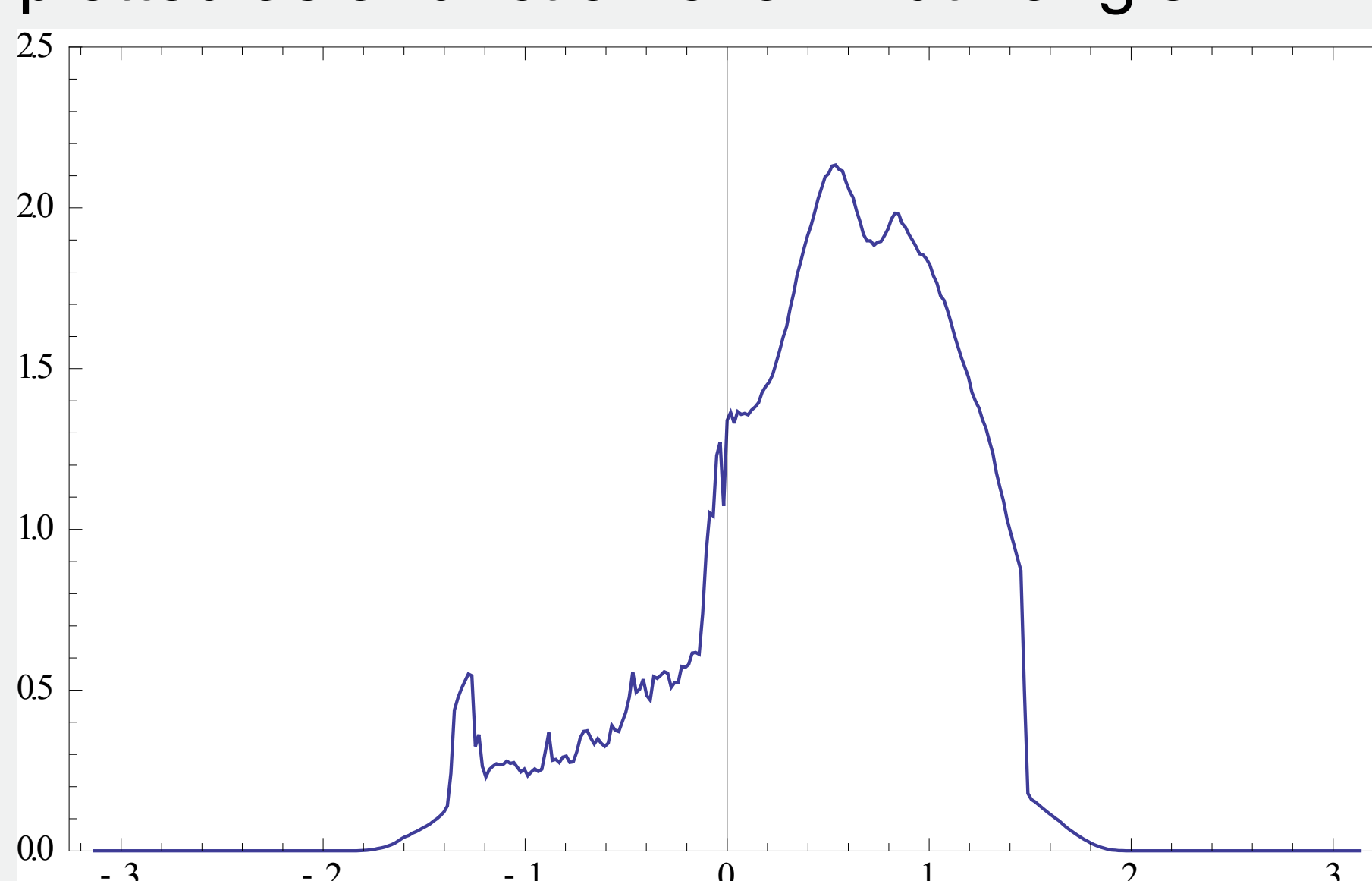


Fig. 4. The measured photovoltaic current from the bifacial PV-cell with the retroreflector (the prototype) is plotted as function of azimuth angle. These data are obtained simultaneously with the solar data used in Fig.3.